Chapter 6

Retrofit of Existing HVAC Control Systems

6-1. Introduction

When determining whether to retain or replace existing control systems (in whole or in part) in the retrofit of existing HVAC systems, the designer must evaluate the applicability of the design guidance provided in this manual. The reason for this evaluation is that deviation from this guidance may be necessary in certain circumstances to prevent adverse impacts on the operation and performance of the retrofitted HVAC systems. Examples of control-system situations that require such evaluation are as follows:

a. Reuse of existing valves, where their sizes may affect the existing or new hydronic systems and their pump sizing.

b. Reuse of existing dampers, where their sizes may affect the existing or new air-handling systems and their fan sizing.

c. Replacing three-way valves with two-way valves and vice versa and its effect on hydronic systems and their pump sizing.

d. Partial retrofit, where only the final elements such as dampers, valves, and operators may be left in place.

e. Retrofits involving economizer control loops.

f. HVAC systems that may not match the systems shown in chapter 4 or their variations in chapter 5.

6-2. Valve sizing and Its effect on hydronic systems

Quite likely the guidance provided in this manual for the sizing of control valves differs from the design criteria on which the existing control valves (in a retrofit project) were selected. Consequently, the designer must compare the pressure drop across the existing control valve with the pressure drop for a control valve based on the sizing requirements of this manual. If the existing valve sizes do not meet the pressure-drop requirement for sizing valves in accordance with this manual, it may be that the sizing of the existing valves was based on pressure drop through the valves lower than required by the manual. The designer must then determine if the existing pumping system can provide adequate flow throughout the system with new valves (sized in accordance with this manual) in place. If not, the existing pumping system will have to be upgraded or replaced if the valve-sizing pressure-drop guidance of this manual is applied.

6-3. Damper sizing and its effect on air-handling system

Evaluation of control dampers in a retrofit project is similar to control-valve evaluation, because changing the size of an existing damper would change the damper's pressure drop and in turn affect fan air-volume delivery. Also, the damper actuators might have to be retrofitted if the evaluation shows a change in the damper's pressure drop.

6-4. Replacement of 3-way and 2-way valves

Whenever there is a change in the type of control valve in a retrofit project (either from a 2-way valve to a 3-way valve or vice versa), the designer must make additional pressure and flow evaluations. If the change is from 3-way to 2-way, the pressure could increase significantly with a significant pumping system flow decrease as the valve closes. Conversely, the change from 2-way to 3-way could cause significant pressure decrease and flow increase. In either case, there could be adverse effects on HVAC system performance. The designer must evaluate and account for the new pressure drops in deciding whether to change the type of valve.

6-5. Retrofit projects where only final elements may be left in place

Some HVAC retrofit projects may involve new controls but may not require replacement of existing primary elements such as dampers, valves, sensing elements, or other measurement devices. In such instances, the designer must insure that the control signals (both input and output) and actuators for the final elements are in accordance with the design guidance provided in this manual.

6-6. Retrofits involving economizer control loops

If an HVAC system with an economizer mode of operation is to be retrofitted, or if an economizer mode is to be added to an existing HVAC system, the economizer components must be in accordance with the guidance described in the manual.

6-7. Retrofit projects involving HVAC systems not covered in this manual.

When an individual HVAC control system not shown in this manual requires upgrading, it may not be feasible nor suitable to follow the guidance of this manual. It is most likely that maintaining consistency with the remainder of the control system is of more value. It is the responsibility of the designer to evaluate existing conditions to determine the suitability of following the guidance of this manual.

6-8. General considerations for retrofit projects.

a. Only electric or electronic terminal-unit controls, if serviceable, may be reused.

b. No existing pneumatic controls except pneumatic valve actuators and damper actuators, if serviceable, may be reused.

c. If pneumatic actuators are to be reused and the designer finds that their use is justified on the basis of life-cycle cost, the existing air compressors and related accessories, if serviceable, may be reused.

d. Electric or electronic HVAC control systems with standard signal levels (i.e., 4—20 ma) if serviceable, may be reused.

e. If existing HVAC systems are retrofitted with control systems designed in accordance with this TM, extension of EMCS to such HVAC systems will interface with the control as shown in this TM.

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Glossary

Section I

Terms, Abbreviations and Acronyms

=	Equal to
<	Less Than
>	Greater Than
A	Ampere
AAD	Auxiliary Actuator Driver
AC	Alternating Current
Accuracy	The degree of conformity of an indicated value to a recognized accepted standard value.
Actuator	A device, that either electrically, pneumatically, or hydraulically operated, changes the position of a valve or damper.
AD	Control Damper
AFMA	Air-Flow Measurement Station
AHU	Air-Handling Unit
AI	Analog Input
Analog	A signal type representing a system variable (such as temperature, humidity, or pressure) that can be measured continuously over a scale.
AO	Analog Output
AUTO	Automatic
Automatic Temperature Control	A local loop network of pneumatic or electric/electronic devices that are interconnected to control temperature.
AUX	Auxiliary
Auxiliary Actuator Driver	An actuator circuit that can be used to control a separate actuator.
Bias	A single-loop digital controller function which maintains a fixed difference in engineering units between controller setpoint and the remote setpoint signal to the controller in engineering units.
BLR	Boiler
C	Common
Cavitation	A phenomenon that results in valve damage from too great a pressure drop through a valve.
CB	Circuit Breaker
CC	Cooling Coil
CDHR	Condenser, Hydronic Return
CDHS	Condenser, Hydronic Supply
CFM	Cubic Feet Per Minute
CH	Chiller

CLK Time Clock

Closed Loop System Control system configuration that allows system feedback.

COND Condenser

Controlled Device The instrument that receives the controller's output signal and regulates the controlled process.

Controlled Variable The temperature, humidity, or pressure value to whose variations the controller responds. Controlled variable is also called process variable.

Controller The instrument that measures the controlled variable and responds by producing an output signal that holds the controlled variable within preset limits.

Controller Feedback The change in the controller's output in response to a measured change in the controlled variable that is transmitted back to the controller's input.

Control Point The actual value at which a controller is holding a process variable.

Controller Configuration Information manually entered through a controller keyboard which selects built-in controller options and sets controller parameters.

Control-Point Adjustment (CPA) Adjustment of a controller's setpoint. The control-point value may vary from the setpoint due to load offset. Control-point adjustment can be accomplished by a signal generated from a local adjustment device, by a signal generated from a remote location, or by means of software.

Controls Devices that govern the performance of a system.

COOL Cooling

CPA Control-Point Adjustment (Remote-Setpoint Adjustment)

C.T. Cooling Tower

CUH Cabinet Unit Heater

C_v The liquid flow coefficient of a valve that has the units of gpm per psid and is used to select the valve for a required flow in the open position at a calculated pressure drop.

D Derivative Control Mode

DA Damper Actuator

DC Direct Current

DD Dual Duct

Deadband A range of thermostat output signal, between the shutoff of heating and start of cooling, in which no heating or cooling energy is used.

DEG Degree

Derivative (D) Mode Control mode in which the output is proportional to the rate of change of the input.

Deviation Contact (DEV) A single-loop digital controller output contact that can be configured to respond to a given difference between the setpoint of the controller and the process variable input signal.

DI Digital Input

DIA Diagram

Differential The difference in values of the controlled variable that will cause a two-position controller to change its output.

Differential Pressure The difference between the static pressures measured at two points in an HVAC system.

Digital Single-Loop Controller A controller that accepts analog input signals, processes the signals digitally according to the controller configuration, and, as a result, produces analog output and two-position output signals.

Direct Acting An output signal that changes in the same direction as the controlled or measured variable. An increase in the controlled or measured variable results in an increase in the output signal.

DMPR Damper

DO Digital Output

DPI Differential-Pressure Gauge

DPDT Double-Pole, Double-Throw

DPS Differential-Pressure Switch

DPST Double-Pole, Single-Throw

DPT Differential-Pressure Transmitter

DX Direct-Expansion Coil

EA Each

EC Economizer Controller

ECON Economizer

Economizer Mode The control system mode of operation in which outside air is used for free-cooling of building spaces.

EF Exhaust Fan

EMCS Energy Monitoring and Control Systems used in military facilities for supervisory control of HVAC control systems and energy-related monitoring and control functions.

EP The acronym for a two-position electric-solenoid-operated 3-way air valve. (Electric to pneumatic.).

Equipment Schedule A listing of control devices by loop function, unique identifier, setpoints, ranges, and other parameters.

ES End Switch

EXH Exhaust

F Fahrenheit, Friday

FC Flow Controller

FCU Fan-Coil Unit

FE Flow-Sensing Element

FLTR Filter

FPM Feet Per Minute

FPS Feet Per Second

Free-Cooling Cooling without mechanical refrigeration.

FT Flow Transmitter

FTR Finned-Tube Radiator

Function Module A device for performing a control-loop function between the transmitter and the controller or between the controller output and the controlled devices.

Gain The amount of change in controller output per unit change of controller input.

GC Glycol Coil

GPM Gallons Per Minute

H High

HC Heating Coil

HD Head

Heat Heating

HFER Humidifier

HL High Limit

HOA Hand-Off-Automatic

HP Horsepower

HPS High-Pressure Steam

HR Heat Recovery

HRC Heat-Recovery Coil

HRS Hours

HS Manual Switch

HTHW High-Temperature Hot Water

HVAC Heating, Ventilating, and Air Conditioning HWS Hot Water Supply HX Heat Exchanger (Converter)
Hydronic A term used to describe HVAC systems using liquid heating and cooling media.

HZ Cycles Per Second (Hertz)
Integral Control Mode

IH Infrared Heater

Input Signal The variable signal, received by an instrument, which provides that instrument with a means of changing its output signal.

INV Signal-Invertor Module

IO Input/Output

P The acronym for a current to pneumatic signal transducer. (I for current and P for pneumatic.)

Integral (I) Mode Control mode in which the output is proportional to the time integral of the input; i.e., the rate of change of output is proportional to the input.

IV Inlet Vane

L1, L2, N Control-Power Lines and Neutral

L Low

Ladder Diagram A diagram that shows the electrical control-logic portion of a control system.

LD Loop Driver

LDR Ladder

Linearity A relation such that any change of input signal is accompanied by a similar output change that is directly proportional to the input.

Local-Loop Control The local pneumatic or electric/electronic controls for any system or subsystem.

LOC Location

Loop Driver A device used in control loops to assure that the single-loop digital controller will not be required to drive a loop with a greater impedance than 600 ohms.

LPS Low-Pressure Steam

LTHW Low-Temperature Hot Water

M Main Air, Motor, Monday

MA Milliamp

MAN Manual

Manual Reset The act of manually restoring control-circuit electrical continuity after the circuit has been opened by a safety device. A feature of the single-loop digital controller that allows manual adjustment of the analog output signal when proportional mode control is used without integral mode control or derivative mode control.

Measured Variable The uncontrolled variable (such as temperature, relative humidity, or pressure) sensed by the measuring element.

Microprocessor Controller A microprocessor-based controller (non-analog in processing its internal signals) that performs a dedicated function and does not require software programming.

MIN Minimum

Minimum-Position Switch A manual switch used to set the position of mixing plenum control dampers to assure that the minimum quantity of outside air is introduced by an HVAC system.

M0l, M02 Magnetic-Starter Holding coil

Modulating Control Control achieved by gradually changing a controller analog output signal to an actuator in response to a change in a sensed variable.

MPS Minimum-Position Switch

MZ Multizone

Normally Closed A controlled device that closes when its power supply or input signal is removed.

Normally Open A controlled device that opens when its prower supply or intput signal is removed.

Normal Mode The usual or expected operating condition.

OA Outside Air

OCC Occupied

Offset The difference between the setpoint of a controller and the actual point of the controlled variable, caused by changes in load.

OL Overload

Open-Loop System Control-system configuration that does not have system feedback.

OUT Output

Output Signal A signal produced in response to an input.

P Proportional Control Mode

Parameter Information and values to be used in configuring a microprocessor controller for its purpose in the control-system application.

PB Proportional Band

PC Outside-Air Preheat Coil, Pressure Controller

PE Pneumatic-Electric Switch

PH Phase

PI Pressure indicator (Gauge) or Proportional-Plus-lntegral Control Mode

PID Proportional-Plus-Integral-Plus Derivative Control Mode

PL Pilot Light

Positive Positioner A mechanical device that measures actuator position and control signal value and sends main air to the actuator to maintain the correct position for the signal.

PP Positive Positioner

Process Control The science of regulating variables by measuring, processing, and manipulating process variables coupled to the regulated variables.

Process Variable See Controlled Variable.

Process Variable Contact (PV) A single-loop digital controller output contact that can be configured to respond to a given value of the process variable input signal.

PROP Proportional

Proportional Band A controller parameter setting which determines the change in the number of engineering units of a process variable input signal that will produce a full-scale change of the controller analog output signal.

Proportional (P) Mode Control mode in which there is a continuous linear relationship between the input and the output.

Proportional-Integral (PI) Mode Control mode in which the output is proportional to a linear combination of the input plus a value proportional to the time integral of the error between setpoint and control point.

Proportional-integral-Derivative (PID) Mode Control mode in which the output is a value proportional to the input, plus a value proportional to the time integral of the error between setpoint and control point plus a value proportional to the time rate of change of the error.

PS Positive Positioner

PSI Pounds Per Square Inch

PSIA Pounds Per Square Inch, Absolute

PSID Pounds Per Square Inch, Differential

PSIG Pounds Per Square Inch, Gauge

PV Process Variable

R Relay

RA Return Air

Range The upper and lower limits of the value of a variable.

Ratio A single-loop digital controller feature which multiplies the remote setpoint input signal to the controller by a constant and uses the resulting value as the controller setpoint.

Relay An electric device that changes the position of its contacts when its coil is energized.

Remote Setpoint Resistance Temperature Detector (RTD) See Control Point Adjustment. A device whose resistance changes linearly as a function of temperature.

REV Reverse-Acting

Reverse Acting An output signal that changes in the opposite direction from the controlled or measured variable. An increase in the controlled or measured variable results in a decreased output signal.

RF Return Fan

RH Relative Humidity

RHC Relative-Humidity Controller, Reheat Coil

RHT Relative-Humidity Transmitter

RHY Humidity Loop Device

SA Supply Air

SAT Saturday

Schematic A diagram that shows the relationship of control devices to control loops and shows the relationship of control loops to systems.

SCIM Standard Cubic Inches Per Minutes

Self-Tuning A single-loop digital controller feature that, when selected, commands the controller to calculate the optimal proportional, integral and derivative mode constants for the process being controlled and to use the calculated constants for control.

Sensitivity The unit change in controller output per unit change in the controlled variable. Usually expressed in psi or milliamps per degree, cfm, etc.

Sensing Element A device used to detect or measure physical phenomena.

Sequence of Operation A narrative that describes the actions of control devices such as valves and dampers as the process variable changes in a given direction, such as on a temperature, humidity, or pressure increase.

Setpoint The desired value of the controlled variable at which the controller is set.

SF Supply Fan

SHLD Sunshield

Signal Inverter A device that linearly converts a 4 to 20 milliampere input signal to an output signal of 20 to 4 milliamperes.

Signal Selector A device that selects the highest or the lowest of its input signals as its output signal.

SMK Smoke Detector

Smoke Detector A generic term for devices that are used to operate safety circuits on the detection of smoke or products of combustion.

SP Static Pressure

S.P. Set point

Span The number of engineering units between the extremes of a calibration range.

SPRG Spring Range

Spring Range The range over which the input signal to a controlled device must change to move the device from one extreme to the other.

SPT Static-Pressure Transmitter

SQCR Sequencer

STM Steam

SUN Sunday

Sunshield A device installed outdoors on the surface of a building to house outside-air temperature-sensing elements and to shield them from direct exposure to sun's radiation.

Supply Pressure Gauge pressure of the compressed air supplied to a pneumatic control system, usually 20 psig.

Supply Voltage Voltage of the electric energy supply to an electric/electronic control system.

Surge Protection Methods of protecting signal wiring and power wiring circuits from damage by electrical voltage and current overrange due to such factors as lightning strikes.

System Feedback System's response to the controller's action in changing the value of a controlled variable, as transmitted back to the controller.

SZ Single Zone

T Modulating Thermostat, Tuesday

TC Temperature Controller

TDR Time Delay Relay

TE Temparature-Sensing Element

TEMP Temperature

Terminal Unit A unit through which heating or cooling is distributed to the conditioned space. Terminal units include radiators, unit heaters, gas-fired infrared heaters, variable-air-volume boxes, duct heating coils, and fan-coil units.

TH Thursday

Thermostat A device that senses temperature and changes its output as a result of temperature changes.

Throttling Range The portion of the instrument range of a controlled variable required to move the controlled device from one extreme to the other.

TI Thermometer

Time Clock A device that changes the positions of its output contacts according to a timing schedule. Transmitter A transducer that senses the value of a variable and converts this value into a standardized transmission signal.

TS Non-Modulating Space Thermostat or Aquastat

TSL: Low-Temperature-Protection Thermostat or Nightstat, Non-modulating

TSP Temperature-Setpoint Device

Tuning The process of finding the control-mode constants the use of which results in the stable control of a process at or near the controller setpoint.

TuP Microprocessor Room Thermost

TT Temperature Sensor and Transmitter

Two-Position Control Control achieved by switching a controller output signal on and off in response to a change in a sensed variable.

TV Temperature Loop Device

UH Unit Heater

Unique identifier An alphanumeric identifier that consists of: 1) an abbreviation for the type of device; and 2) a number made up of an HVAC-system number and a serial number for the device.

UNOCC Unoccupied

VAV Variable Air Volume

VFDU Variable-Frequency Drive Unit

VLV Valve

W Wednesday

WTR Water

X1, X2 transformer Power, Hot and Ground

X Times (Multiplication)

XMFR Transformer